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OPTIMATION, INC.

# INSTRUCTION MANUAL

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## PRECISION AC INSTRUMENTS

OPTIMATION, INC. 9421 telfair ave., sun valley, calif. 91352 768-0880

AC-15

PRECISION AC POWER SOURCE

(SEE SPECIAL INSTRUCTIONS ON FOLLOWING PAGE)

# SPECIAL MANUAL INSTRUCTIONS

# FOR

# MODEL AC-15

The Model AC-15 AC Precision Power Source is the same as the Model RCD-6, except that the .05% distortion specification extends down to 90Hz on the AC-15, rather than 20Hz on the RCD-6, as shown on Page 1-4 of this manual.

With the above exception, this manual applies to the AC-15, although the manual refers to the original model designation of the equipment, RCD-6.

Minor apparent discrepancies between the AC-15 and the manual should be resolved with the above information.

For reference purposes, a data sheet describing the AC-15 is included in this manual.

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## Section I

## GENERAL INFORMATION

### 1.1 SCOPE

This publication is the basic handbook of instructions for operation, service and maintenance of Optimation, Inc. RCD Series Power Oscillators. It presents a detailed description of the units as follows:

1. General Description and Specifications.
2. Installation information.
3. Operating instructions.
4. Principles of operation.
5. Maintenance.
6. Table of replaceable parts.

### 1.2 APPLICATIONS

The RCD Power Oscillators are intended for use in laboratory applications where requirements exist for AC signals over the frequency range of 0.1 to 100,000 cycles with a high degree of amplitude stability and purity of waveform.

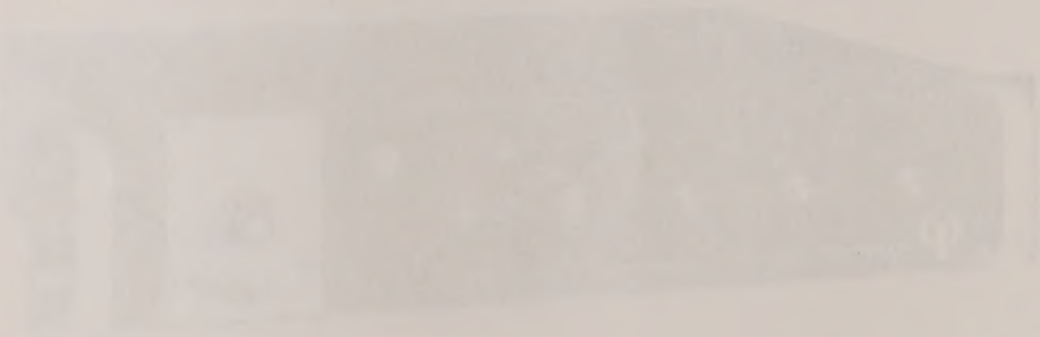
The excellent performance characteristics of the RCD Power Oscillators make them ideal for use as a source in AC voltage and current calibration work, galvonometer calibration, precise distortion measurements, vibration calibration and testing, filter and transformer testing, and other applications in the sub-sonic through ultra-sonic regions. The all silicon solid state amplifier section provides 15VA (25VA optional) of precise AC power output.

Two phase versions with a power output of 15VA per phase are also available. These units are ideal for gyro power supplies, phase measurements and calibration, wattmeter calibration, and other applications requiring two phase power. The phase angle tracks with frequency thus providing phase to phase accuracy over a wide frequency range.

### 1.3 DESCRIPTION

The RCD Power Oscillators cover the frequency range from 0.1 to 100,000 cps and are designated by Model Nos. RCD-6R or RCD-7R. These units are suitable for rack mounting. The RCD-6R is a standards laboratory power oscillator and the RCD-7R a 4-digit accurate frequency power oscillator. The suffix "R" denotes rack mounting.

Figure 1-1 RCD POWER OSCILLATOR 1-2



### 1.3.1 Electrical Description

The RCD-6R and 7R are ultra high purity sign wave power oscillators with in-line digital frequency readout that can be set from 0.1 to 99,900 cps on the RCD-6R and 0.01 to 99,990 cps on the RCD-7R. A variable vernier frequency control allows overlapping coverage for the least significant digit and permits the oscillator to be set at frequencies up to 100,000 cps.

The maximum open circuit output voltage is 16 volts RMS nominal. Some models have an output matching transformer to provide higher output voltages. On these units the low frequency limit will be 10 to 100 cps depending on the particular model transformer utilized. The output voltage is controlled by a fixed step attenuator mounted concentrically with a variable vernier attenuator. The output of the unit is protected against short circuits. If a short circuit is applied the overload circuit will operate preventing damage to the output transistors.

The circuitry (patent applied for) employs one premium frame grid vacuum tube, 19 transistors, and other diodes and zener diodes. The 25VA units utilize 21 transistors. Two phase units utilize 2 vacuum tubes and 32 transistors.

A unique DC amplifier circuit plus a bridged-T RC frequency determining network enables the oscillator to provide an output signal with extremely low distortion. A specially designed amplitude sensing element is utilized in a positive feedback loop to maintain jitter, noise and short-term amplitude variations at very low values (see Table 1-1). Amplitude stability is further enhanced by the constant gain characteristics of the DC amplifier and by close regulation of power supply voltages.

The power amplifier section has extremely stable gain, very low distortion and a high degree of regulation.

A special clipping circuit set approximately 5 per cent above the nominal output voltage, minimizes the oscillatory amplitude variations and transient outputs that normally accompany changes in frequency of RC bridge type oscillators.

Excellent frequency stability is achieved by utilizing high quality polystyrene capacitors and metal film resistors having complementary temperature coefficients in the frequency determining bridged-T network.

Special frequency instability of 0.0005% short term is available in optional "C" versions of the power oscillator. Aged and stabilized components having near zero temperature coefficient are utilized in these versions.

Table 1-1 Essential Electrical Characteristics of RCD-6R Power Oscillator

| CHARACTERISTIC | VALUE OR DESCRIPTION |
|---|---|
| **FREQUENCY** | |
| Range | 0.1 to 99,900.cps |
| Calibration Accuracy, in CALIB position, 10 to 99,900.cps. | ±1% |
| Instability[1], 1 hour, constant temperature. | 0.01% |
| Instability, long-term effects | 0.25% |
| Response, 10 to 9,990 cps | ±0.5% |
| **PURITY** | |
| Distortion | 0.05% 20 to 10,000 cps, 0.1% @ 20,000.cps |
| Hum & Noise | 0.01% of Rated Output. |
| **AMPLITUDE** | |
| Instability[1], 1 hour, average or RMS, constant temperature. | within 0.01% |
| Instability with 10% line voltage change | 0.01% |
| Line Intermodulation, at or near line frequencies | < 0.1% |
| **OUTPUT** | |
| Power, 0.1[2] to 70,000 cps (100,000 cps 15VA -3 db) | 15VA+1db. |
| Voltage, open circuit nominal, direct | 15V RMS |
| Attenuator | |
| STEP | 0, -20, & -40db |
| VERNIER | 0 to 15V on 0 db STEP, 0 to 1.5V on -20 db STEP, & 0 to 0.15V on -40 db STEP. Resolution 0.002% of full scale |
| Impedance | zero. Adjustable to zero on models with output transformer. |
| Coupling | Direct and isolated from ground. DC balance control provided for oscillator and power amplifier sections. Transformer coupled, on units with output transformer. |
| **POWER REQUIREMENTS** | 105 to 130 VAC, 50 to 400 CPS, 65 Watts, a rear mounted switch allows 210 to 260V AC operation. |

NOTE:

1. Specifications are valid after 1-1/2 hour warmup from room temperature.

2. Low frequency limit is higher when optional matching transformers are included.

3. See page 1-5 for typical performance characteristics.

The output is direct coupled and isolated from the outer chassis ground and the third wire of the power cord. Maximum capacitance to the circuit ground is 2000pf.

### 1.3.2 Physical Description

All circuitry for the oscillator, with the exception of the front panel switches and controls, are mounted on a single chassis which is suspended in an inverted position. The outer protective covers and front panel are electrically isolated from circuit ground.

The front panel controls are arranged to provide direct, in-line digital dialing and readout of frequency. A traveling illuminated decimal point is provided between adjacent digits and is set by the range selector switch. The digits are lighted from the rear to provide excellent visibility.

Figure 1-2 shows the outside dimensions of the unit. The 19 inch front panel is designed for mounting in a standard EIA 19 inch rack.

### 1.3.3 Essential Characteristics

The essential electrical characteristics of the oscillator are listed in Table 1-1. Table 1-2 lists the dimensions and weights of the unit and the tube and semi-conductor complement is tabulated in Table 1-3.

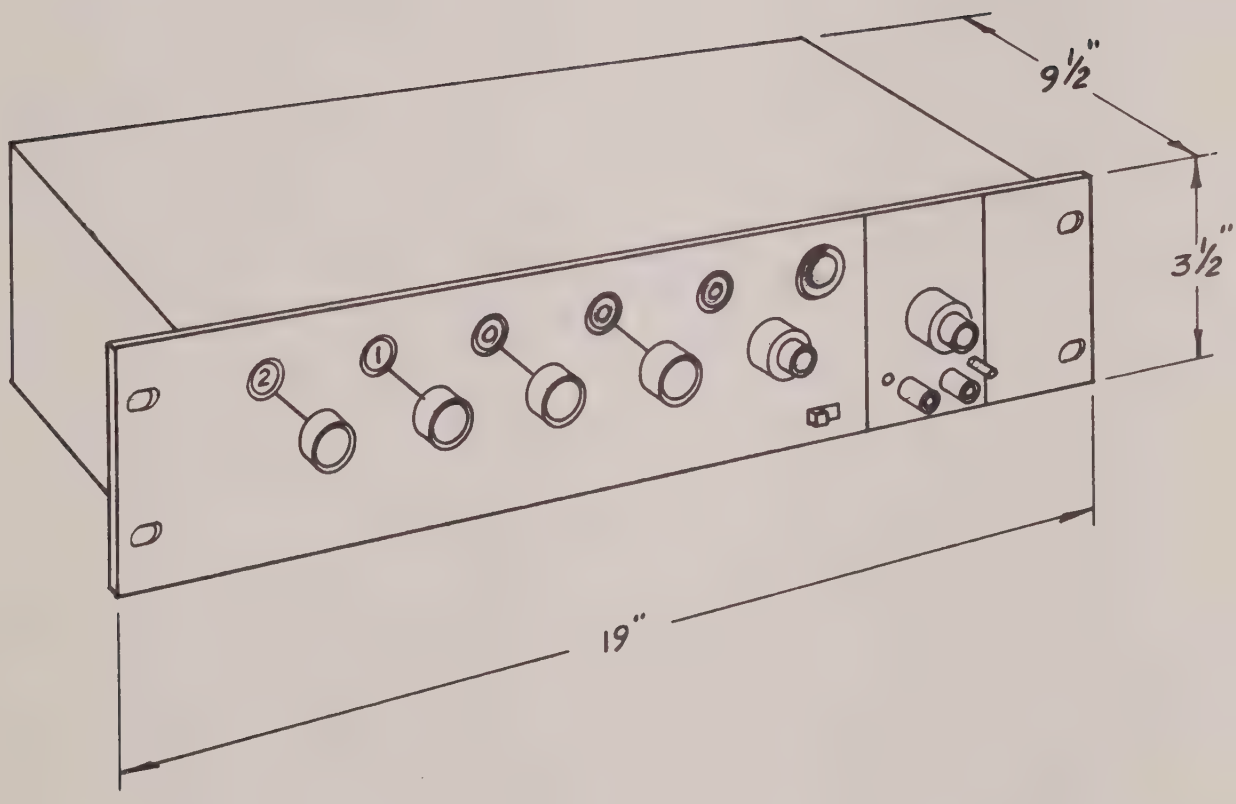



Figure 1-2 Rack Mounting Model RCD Power Oscillator

Table 1-2 Dimensions and Weights of RCD Power Oscillators.

| UNIT | *Overall Dimensions W | H | D | Weight | Shipping Weight |
|---|---|---|---|---|---|
| RCD-6R, 7R | 19 | 3-1/2 | 15 | 24 lb. | 35 lb. |
| With matching transformer. | | | | 30 lb. | 41 lb. |

These weights subject to change.

*All dimensions in inches.

Table 1-3 Tube and Semiconductor Complement.

| TYPE | Reference Designation | Total |
|---|---|---|
| 6DJ8/ECC88 | V1 | 1 |
| 2N3053 | Q1, 4, 5, 7, 102, 105, 111, 112 | 8 |
| 2N3250 | Q2 | 1 |
| TI495 | Q3 | 1 |
| 2N669 | Q6 | 1 |
| 2N3133 | Q101, 103, 110 | 3 |
| 2N3118 | Q104 | 1 |
| 2N1490 | Q106, 108 | 2 |
| Special | Q107, 109 | 2 |
| CD34381* | CR3 | 1 |
| 1N712* | CR4 | 1 |
| CD34371* | CR5 | 1 |
| 1N625 | CR7, 17, 18, 21 | 4 |
| MR1030A | CR13, 14, 15, 16, 108, 109, 110, 111 | 8 |
| 1N3254 | CR101, 106 | 2 |
| 1N935 | CR102, 105, 107 | 3 |
| 1N2994B | CR103 | 1 |
| 1N1598 | CR104 | 1 |
| 1N962B | CR112 | 1 |

* or equivalent

## Section II

## INSTALLATION

### 2.1 UNPACKING AND INSPECTION

#### 2.1.1 Unpacking

All models of the RCD Power Oscillator are packaged for shipment in a two-section "Shell-within-a-shell" cardboard container. After opening both containers, the oscillator can be lifted straight out.

NOTE: Save all packing materials to simplify repackaging if reshipment should become necessary (Paragraph 2.4).

#### 2.1.2 Inspection

Inspect the oscillator for freedom from shipping damage as soon as it is unpacked. In particular make the following checks:

1. Turn the oscillator upside down and remove the 9 6/32 screws securing the bottom protective cover plate. Remove the cover plate.

2. Make sure that the vacuum tube, overload lamps, and amplitude stability regulator lamp are not borken, and that they are firmly seated in each respective socket.

3. Insure that all transistors mounted in heat sinks are firmly seated in the heat sink clips.

4. Make sure that all other components are free of apparent physical damage.

5. Check that all knobs are tight on their shafts and do not bind when turned. Operate controls and switches and check for smoothness of operation. Any binding or jamming indicates abnormal mechanical operation and should be investigated and corrected before operating the oscillator. Do not force any control that does not turn freely or permanent damage may result.

THE POWER OSCILLATOR IS INSURED FOR SAFE DELIVERY. IF SHIPPING DAMAGE IS FOUND, TAKE IMMEDIATE STEPS TO FILE A DAMAGE SHIPMENT CLAIM WITH THE CARRIER AND CONSULT THE WARRANTY STATEMENT AT THE REAR OF THIS MANUAL.

## 2.2 INSTALLATION REQUIREMENTS

### 2.2.1 Bench Use

The power oscillator requires the space indicated in Figure 1-2. Locate the oscillator within 7-1/2 feet of the power receptacle to be used. The oscillator should not be located near equipment whose ambient temperature varies widely. For example, the oscillator should not be placed on top of equipment that emits considerable heat. Wide ambient temperature variations can cause variations in amplitude and/or frequency.

### 2.2.2 Rack Mount

The power oscillator mounts into a standard EIA 19 inch wide rack. The required mounting dimensions are shown in Figure 1-2. The unit must be located within 7-1/2 feet of the power receptacle utilized. Sufficient clearance should be allowed at the rear of the oscillator to assure adequate ventilation. In addition, the oscillator should not be placed in a rack directly above equipment that emits considerable heat.

### 2.2.3 Connecting Output Leads

Output terminals plus a ground terminal are located on the right side of the front panel. They are standard multiple binding posts that will accept GR-type twin banana plugs, space connectors, or tinned leads. Output terminals are also located on the rear of the oscillator.

### 2.2.4 Length and Type of Output Leads

The internal impedance of the power oscillator is zero. It is adjustable to zero on units with output transformers. Therefore, at most signal levels the type and length of output leads are not critical. If the oscillator is being utilized at very low signal levels over long distances, it would be advisable to use shielded cable from the output terminals.

### 2.2.5 Electrical Connections

The RCD Power Oscillator is designed for use with a 110 or 220 volt 60 cycle line voltage. The supply voltage can vary from 105 to 130 or 210 to 260 volts and the frequency can vary from 50 to 400 cycles without affecting the operation or specifications of the oscillator. For 220 volt operation move the rear mounted switch to "220V" position.

To protect operating personnel the oscillator case and front panel should be grounded. This is accomplished when the 3-conductor power cable is plugged into a proper 3-conductor polarized receptacle. The offset pin of the power cable plug is the ground pin. To maintain protection when operating the instrument from a non-polarized two contact outlet, use a 2-prong adapter, and connect the pigtail on the adapter to ground.

## 2.3 INSTALLATION

No special installation is required for bench operation of the power oscillator. To install the unit in a rack, slide it into position from the front of the rack. It is then secured to the rack by means of four 10-32 X 1/2 inch oval head machine screws, washers and nylon inserts; fastened through the slots provided in the front panel.

## 2.4 PREPARATION FOR RESHIPMENT

If reshipment becomes necessary, the power oscillator should be reshipped in the same container in which it was received. Use the same packing material, if it is available. If not available, insure that the unit is packed securely in an inner box. This inner box should then be packed in an outer box with at least 2 inches of shock absorbent material between the two boxes.

## Section III

## OPERATION

### 3.1 GENERAL

The RCD power oscillator has a minimum number of controls and switches and is relatively simple to operate. This section contains general operating instructions and operating procedures for the unit.

### 3.2 DESCRIPTION OF OPERATING CONTROLS AND INDICATORS

Figure 3-1 shows the location of the operating controls and indicators. Their functions are described below:

a. Power Switch:
Turns ON line power to the Power Oscillator. Frequency digit indicators and decimal point will light when unit is ON.

b. Frequency Selectors:
Select the 3 (4 on RCD-7R) most significant digits of the desired output frequency. These are displayed in the first 3 (4 in RCD-7R) digit windows from the left of the Oscillator panel.

c. Frequency Digit Indicators:
The Digit Indicators to the left display the numbers selected by the Frequency Selectors. The digits to the right are fixed zeros and are utilized to complete the frequency readout in cycles per second.

d. DECADE Frequency Range Selector:
Selects one of 4 decade frequency ranges and causes the decimal point to light in the correct place for the respective range selected.

e. Decimal Indicators:
Indicate the position of the decimal point according to the frequency range selected by the DECADE frequency selector.

f. VERNIER Frequency Control:
Allows variation of the output frequency by approximately $\pm$1% ($\pm$0.1% RCD-7R) of the nominal value indicated by the frequency digit indicators. When the VERNIER Frequency Control is placed in the CALIBrate position, indicated on the panel, it is optimized for best tracking over the entire frequency range of the Power Oscillator.

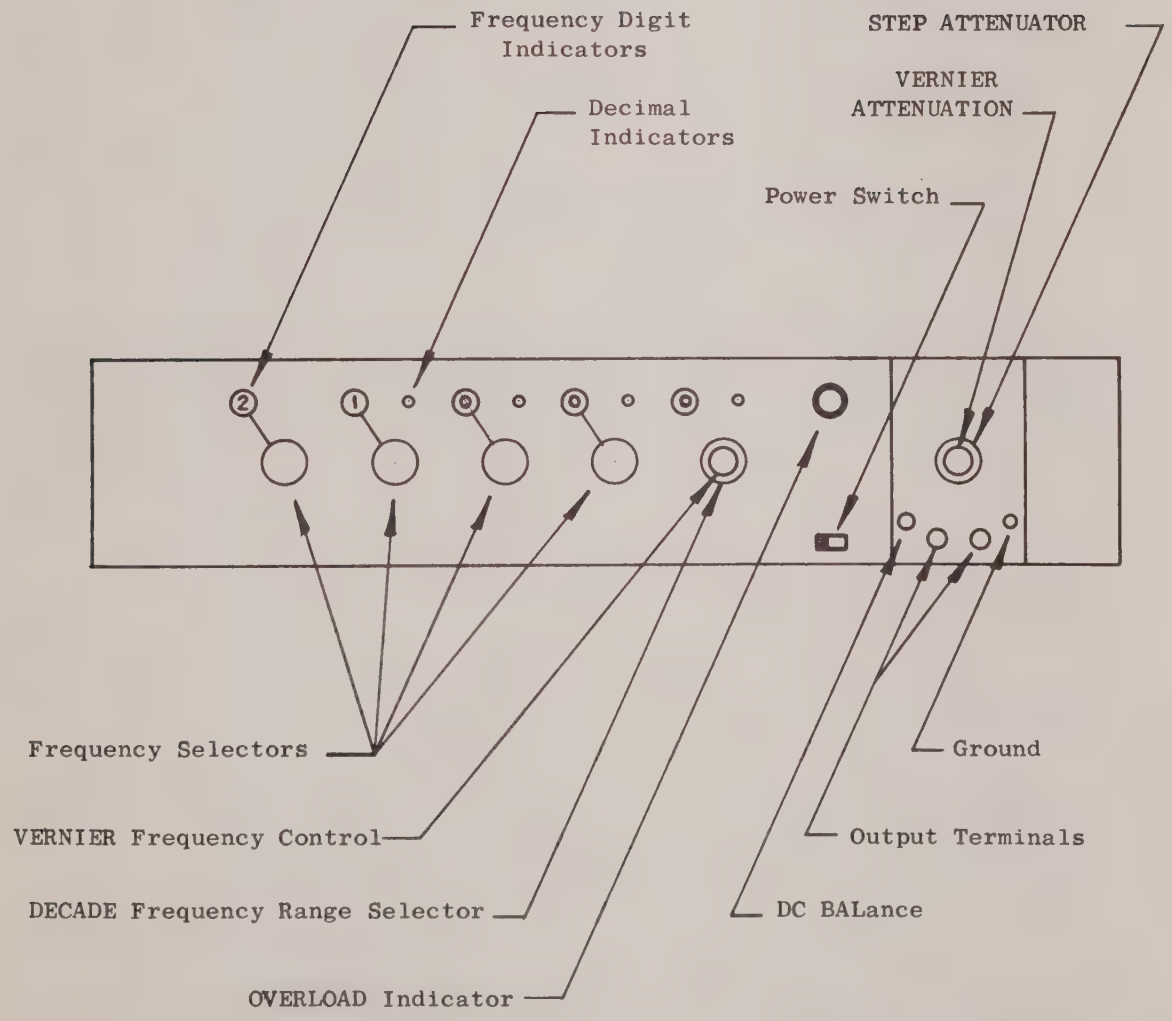



Figure 3-1 Location of Operating Controls

g. STEP ATTENUATION:
The STEP output attenuator has three fixed steps of 0, -20, and -40 db. (Not on some 2 phase models.)

h. VERNIER ATTENUATION:
Provides a continuous variable amount of output ATTENUATION. This control labeled "LEVEL" on some 2 phase models.

i. D.C. BALance:
This is a screwdriver adjustment that allows adjusting the DC component of the Oscillator section to essentially zero. (See paragraph 3.3.1).

j. Output Terminals:
Power Oscillator output voltage.

k. OVERLOAD Indicator:
Glows bright when Power Oscillator is overloaded. This indicator may glow dimly at full power output.

## 3.3 PRELIMINARY PROCEDURES

Before the Power Oscillator is placed in actual operation, the operator should set certain controls. The details of these preliminary procedures are described in paragraph 3.3.1. In the following paragraphs it is assumed that the unit has already been installed and according to procedures in Section II.

### 3.3.1 DC Balance Adjustment

1. Set frequency to 1000.0 cps.

2. Monitor output with a DC voltmeter having a full scale range of 1 to 1.5VDC.

3. Set STEP ATTENUATION Control to 0 db and turn VERNIER ATTENUATION Control fully clockwise (maximum output).

4. DC on output should be less than 100 mv for normal applications. Some applications may require less DC than this on the output. If necessary, the DC Balance Controls should be adjusted as follows:

Amplifier Section

The DC balance controls located on the rear of the chassis are for the power amplifier sections. The front panel control is for the oscillator section.

a. Set VERNIER ATTENUATION Control to zero, (fully counter-clockwise).

b. Attach VTVM or multimeter to Output Terminals. A full scale of 1 to 1.5V DC should be used. Ground low side of output to ground terminal on units with matching transformer.

c. Adjust Ø1 DC BALance for zero indication on the meter. For 2 phase power oscillators, repeat steps b & c for Ø2 using Ø2 DC BALance control.

Oscillator section DC BALance (Do after amplifier DC BALance).

d. Set Output Amplitude VERNIER to maximum output (fully clockwise).

e. Adjust front panel DC BALance for zero DC output.

NOTE: The DC Balance controls should require very infrequent adjustment.

## 3.4 OPERATION

To place the Power Oscillator in operation proceed as follows:

a. Put the Power Switch to the ON position. The Digit Indicators and Decimal Indicators will light indicating the power is ON. Allow approximately five minutes for warm-up.

b. Select the desired operating frequency using the Frequency Selectors and the DECADE Frequency Range Selector. The frequency will then be read out on the Digit Indicators directly in cycles per second. Clockwise rotation of the DECADE Frequency Range Selector moves the decimal point to the right and vice versa. For best performance the most significant digit of the frequency selected should always be set on the extreme left-hand (facing the instrument) Frequency Selector. The reason for this is explained in paragraph 4.3.1 of Section 4.

c. Set the VERNIER Frequency Control to the CALIBrate position.

NOTE: The VERNIER Frequency Control is positioned on the shaft at the factory for the best average frequency accuracy over the entire range of the oscillator, with the knob in the CALIBrate position. This control can be adjusted for greater accuracy at a specific frequency by utilizing an external frequency counter. A detailed analysis of the VERNIER Frequency Control is given in paragraph 4.3.2 in Section 4.

d. Adjust signal amplitude by setting the STEP ATTENUATION Control and the VERNIER ATTENUATION Control.

e. Matched load impedance for maximum power transfer ranges from 5 to 12 ohms on 15VA units and 3 to 8 ohms on 25VA RCD Power Oscillators.

## Section IV

## PRINCIPLES OF OPERATION

### 4.1 INTRODUCTION

This section describes the principles of operation of the RCD Power Oscillators. It is recommended that any person attempting to adjust or trouble-shoot the oscillator read and thoroughly understand the material presented in this section before any work is done on the unit.

### 4.2 FUNCTIONAL DESCRIPTION

#### 4.2.1 Basic Oscillator Operation

Figure 4-1 shows a simplified equivalent circuit for the RCD series Power Oscillators. Basically, the oscillator section consists of a differential amplifier having a highly stable gain of 30 with positive feedback applied through the network of AR1 and R-1 and negative feedback applied through the bridged-T frequency determining network. When the net feedback applied to the differential amplifier $A_1$ is positive the unit will oscillate at a frequency where the transmission characteristic is at minimum and the phase shift is zero (Figure 4-2).

a. When the oscillator is first turned on approximately one-half of the output voltage of the amplifier is applied through the positive feedback loop to the input of the amplifier.

b. The negative feedback is approximately one-third of the output amplitude at the frequency of oscillation and remains constant.

c. Since the positive feedback is greater than the negative feedback the unit will immediately go into oscillation.

d. As AR1 warms up its resistance value goes up and the positive feedback is reduced. The positive feedback stabilizes at a value slightly above the amount of negative feedback.

e. AR1 is the stabilizing element and consists of a specially designed lamp having a mechanically stable tungsten resistive element in a vacuum. It provides amplitude stabilization for the oscillator and works as follows: If the output amplitude of the oscillator tends to go up the voltage across AR1 increases thereby increasing the temperature of AR1 which in turn increases its resistance. This causes the amount of positive feedback applied to the differential amplifier to decrease. The net signal into the differential amplifier is thereby lowered to the original value stabilizing the output amplitude.

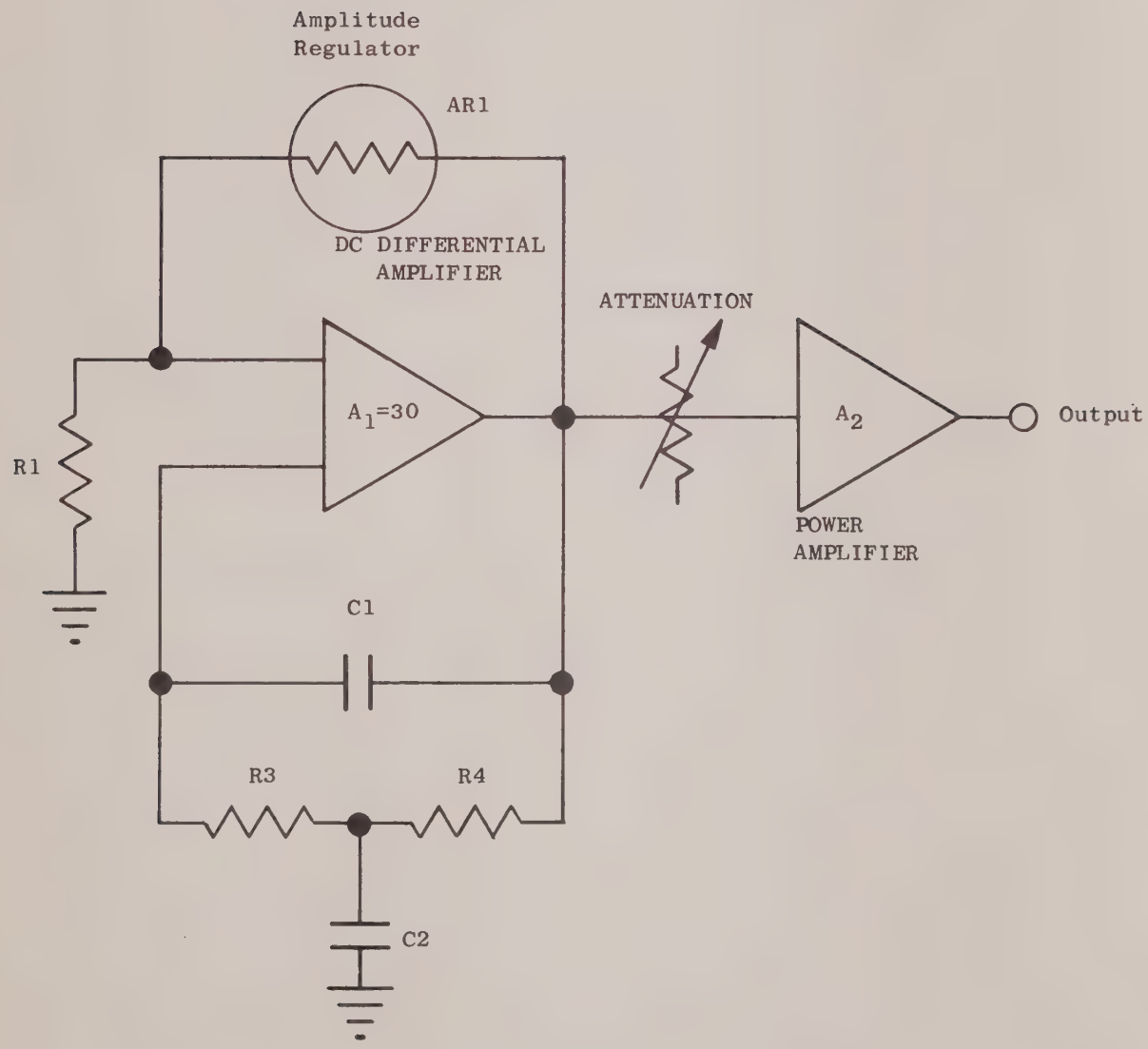
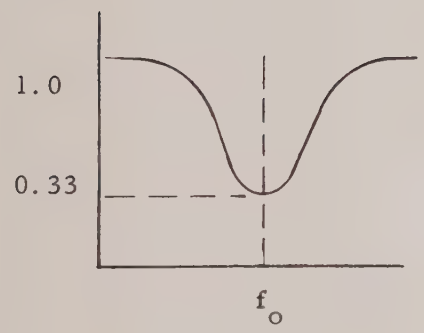
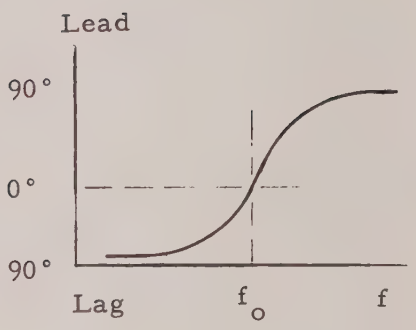



Figure 4-1

RCD POWER OSCILLATOR EQUIVALENT CIRCUIT




Transmission Characteristic




Phase Shift

Figure 4-2 Bridged-T Characteristics

The amplitude stabilization element AR1 is very sensitive and requires very low power to exercise precise amplitude control. Actually it consumes less than 1/20th of a watt. The excellent control of the amplitude stability element in conjunction with the high gain stability of the differential amplifier without feedback combine to provide the very high order of amplitude stability in the RCD series Power Oscillators.

### 4.2.2 Bridged-T-Network

The bridged-T frequency determining network has transmission characteristics illustrated in Figure 4-2. At the frequency of oscillation transmission is at a minimum and phase shift is zero. The ratio of C-1 to C-2 determines the steepness of the slope of the transmission characteristic. This steepness in part determines the degree to which harmonics are attenuated. The ratio of C-1 to C-2 is 4:1, an optimum value taking into consideration steepness and practical size of capacitors. For example, with the bridged-T network utilized in the RCD oscillators the response to the second harmonic of the frequency of oscillation is up 6 db through the bridged-T network. The third harmonic is up 10 db, and high order harmonics approach a maximum of about 20 db. Therefore, since the bridged-T network is supplying negative feedback, the distortion due to the second harmonic is reduced by one-half (compared to the amplifier $A_1$ alone); the third to one-third, and high order harmonics to one-tenth of their value in the differential amplifier $A_1$ alone. It is interesting to compare this with the standard Wein bridge oscillator which uses a typical capacitor ratio of 1:1. The 1:1 ratio means that the Wein bridge has a lower equivalent Q factor and therefore does not have the distortion reducing properties of the 4:1 bridged-T. Hence, in general for a particular differential amplifier the distortion of the Wein bridge oscillator will be higher.

### 4.2.3 Power Amplifier Output

The power amplifier stage provides either 15VA or 25VA output (depending on model) to matched loads.

### 4.2.4 Oscillator Circuit Description

Figure 4-3 shows a more detailed functional block diagram of the RCD Oscillator series. In following this discussion it will be useful to refer to the schematic diagram of the Oscillator at the rear of this handbook.

The differential amplifier basically is contained in VI a dual triode. Q1 is utilized to provide a constant source of cathode current to V1. Q2 supplies a constant source of plate current to V1A. Looking at Q1 and Q2, V1 sees a very high impedance. Hence, the current from Q1 and Q2 is constant.

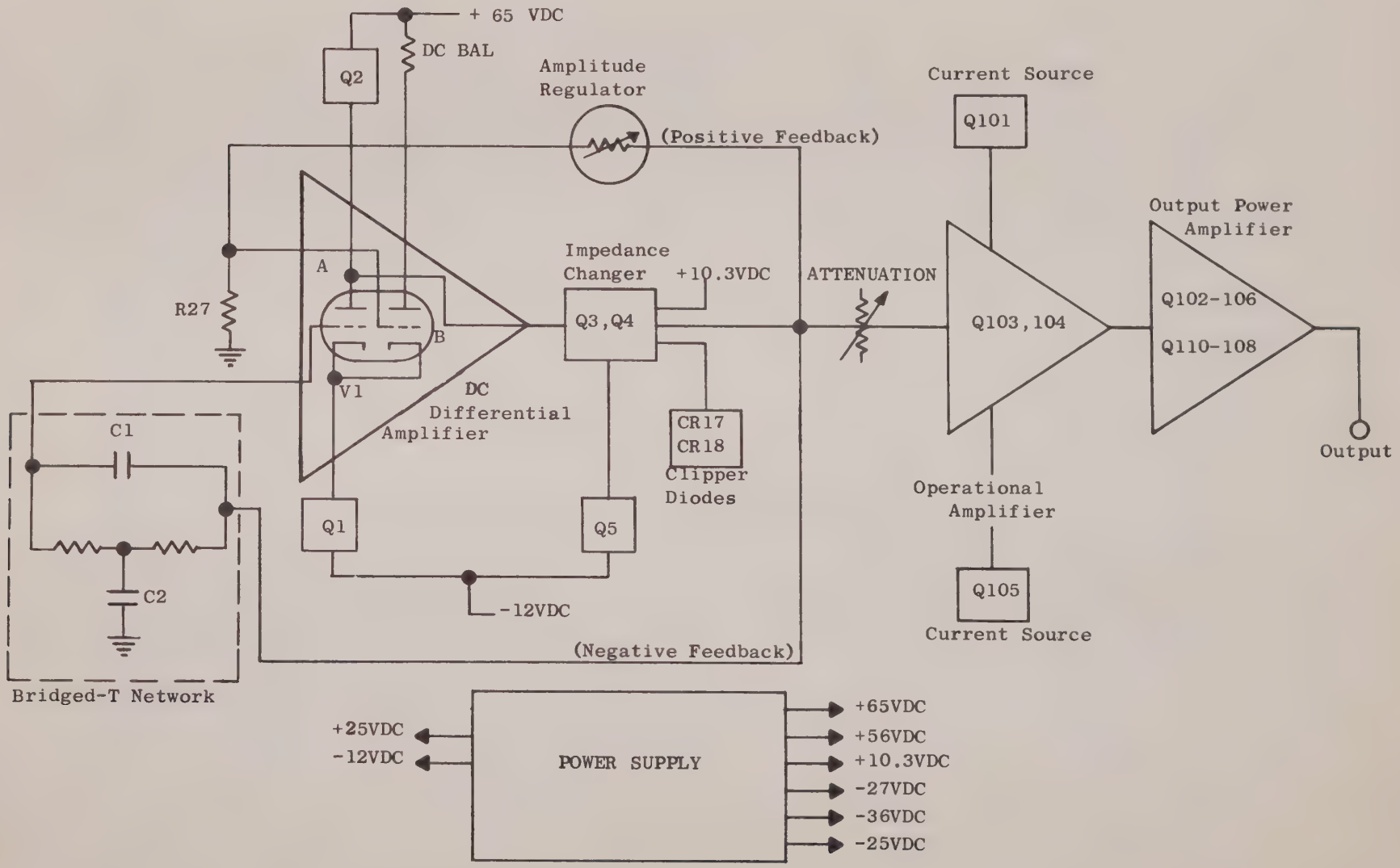



Figure 4-3

RCD POWER OSCILLATOR BLOCK DIAGRAM

In this configuration the gain of the differential amplifier approximates the mu of the tube which is about 30. This gain remains constant over a wide range of external parameters. Since the mu of the tube is determined primarily by the spacing of the elements within the tube, the gain remains fixed. This circuit is unique and the subject of a Patent Application.

One side of the differential amplifier input is fed by the bridged-T network supplying negative feedback. The other side of the differential amplifier is fed by the amplitude stability regulator which supplies positive feedback.

The output impedance of V1 is relatively high. This is reduced to a low value by the impedance changing action of Q3 and Q4, a cascaded transistor power output stage connected in an emitter follower configuration. The output impedance of this impedance changer is near zero. The excellent frequency stability of the oscillator is in part due to this near zero output impedance and the nearly infinite input impedance of the V1 differential stage. Q5 is a constant current source for Q3 and Q4. To minimize the recovery time when switching frequencies, diodes CR-17 and 18 are utilized. As the frequency is switched the output amplitude tends to rise. Due to the thermal time lag of the amplitude stability regulator it takes a number of cycles before the amplitude is stabilized. In order to minimize the time required for the signal to restabilize, these diode clippers are set approximately 5 per cent above the nominal output amplitude. When the signal attempts to rise, due to switching frequency, it is clipped by the diodes thus allowing the amplitude stability regulator to "catch up". At high frequencies the recovery time is a fraction of a second. At low frequencies it will be in the order of one to two seconds.

4.2.5 Power Amplifier Circuit Description

The power amplifier input stage is an operational amplifier whose gain is determined by the ratio of $\frac{R105}{R104}$. A relatively high input impedance is facilitated by Q103 (emitter follower) and Q104 (grounded emitter gain stage). The circuit is temperature compensated to maintain constant gain.

Q101 and Q105 are current sources for the operational amplifier stage.

The power amplifier output stage operates single ended push-push. Q102 and 106 are connected in a darlington configuration and operate for positive half cycles. Q110 and Q108 are connected as a feedback pair and operate on negative half cycles.

The output transistors are protected from overload or short circuit by lamps in series with the Q102-Q106 pair and Q110-Q108 pair respectively. These lights provide the overload indication on the front panel.

4.2.6 Power Supply

The power supply provides all voltages necessary for proper Power Oscillator operation. The power supplies are extremely well regulated and the circuitry insures good isolation from line voltage variations. DC on tube filaments insure freedom from line beat.

4.3 OPERATING CONTROLS

4.3.1 Frequency Selection

Frequency selection should be made with the most significant figure of the desired frequency in the left-hand Frequency Digit Indicator. This will provide the maximum amplitude stability, lowest distortion, and best resolution.

Frequencies can be set on the Frequency Selectors in more than one way. For example, 10 cps can be set: (a) 10.000, (b) 010.00 or (c) 0010.0. The example in (a) shows that the resolution is 0.1 cps, while in (b) it is 1.0 cps, and in (c) 10 cps.

The method of frequency selection can be best understood by referring to the simplified equivalent circuit shown in Figure 4-1. The frequency of oscillation can be expressed mathematically by the equation:

$$F_o = \frac{1}{2\pi\sqrt{R_3 R_4 C_1 C_2}}$$

Since $R_3$ equals $R_4$, the equation may be simplified to become:

$$F_o = \frac{1}{2\pi R\sqrt{C_1 C_2}}$$

$R_3$ and $R_4$ represent the first three digits (four digits RCD-7R) which actually consist of 3 or 4-switched resistance decks connected in parallel. The first two significant digits utilize 9 resistors of equal value in progressive shorting configuration. Since frequency is inversely proportional to resistance, the frequency will go up as the resistance R goes down. For example, two resistors in parallel will provide half the resistance and, hence, twice the frequency of oscillation; three in parallel provide one-third the resistance and three times the frequency, etc.

The third and fourth digits use a series "ladder" arrangement of resistors. This series configuration minimizes unwanted capacitive reactance at the higher resistor values required for these digits.

In order for the frequency selectors to be related by decades, the resistors in the second digit will have a value of 10 times those used in the first digit, etc. In the RCD Power Oscillator the first digit utilizes nine 31,350 ohm resistors. The second digit would utilize 313.5K ohm resistors. The third and fourth digits use appropriate values of resistors in the "ladder" for a decade relationship. The differential amplifier $V_1$ (See Figure 4-3) is designed for optimum performance with values of $R_3$ and $R_4$ from approximately 3,000 to 30,000 ohms. Therefore, best performance will be achieved when the most significant digit of the desired frequency is set in the first or left-hand frequency indicator.

### 4.3.2 VERNIER Frequency Control

The VERNIER Frequency Control knob has been positioned on the shaft at the factory so that the best average frequency accuracy over the entire oscillator frequency range will be obtained in the CALIBrate position. For greater accuracy over a limited frequency range, the VERNIER control can be set by use of an external frequency counter. The VERNIER control provides a range of approximately 3 per cent of the dialed-in frequency (RCD-6R); range is 0.25%, RCD-7R.

The VERNIER Frequency control varies the amplitude of the differential amplifier output signal voltage applied to the low-pass portion of the bridged-T network (See Figure 4-1, C2 & R4), while the voltage applied to the high-pass portion (C1 & R3) is maintained at a constant level. Since the resonant frequency of the bridged-T network is determined by summing the transfer functions of the high and low-pass sections in a series manner, the reduction of voltage applied to the low-pass section will raise the frequency of zero phase-shift and, hence, cause a corresponding change in oscillator frequency. This method of vernier frequency change creates no significant change in transmission through the network.

### 4.3.3 Frequency Range Selection

The DECADE frequency range selector switches $C_1$ and $C_2$ to provide the four DECADE frequency ranges of the oscillator. The ratio of $C_1$ to $C_2$ is 4:1 as described in paragraph 4.2.2. The value of capacitors used in $C_1$ ranges from .25 microfarads to .00025 microfarads. $C_2$ ranges from 1 microfarad to .001 microfarads.

In addition to switching capacitors $C_1$ and $C_2$, the DECADE frequency range selector also switches the lights for the decimal indicators, thus providing the correct frequency read-out directly in cycles per second.

### 4.3.4 Output Amplitude Control

The output amplitude is controlled by means of a STEP ATTENUATION Control at fixed steps of 0, -20 and -40 db, and a concentric VERNIER. The STEP control consists of three resistors connected in series with the

output having values of 604, 6.04K, and 60.4K for the three steps of 0, -20 and -40 db, respectively. To provide an internal impedance of 600 ohms, a 665 ohm and 604 ohm resistor are connected from the attenuator resistor to ground on the -20 and -40 db STEPS, respectively (see schematic diagram).

The VERNIER control provides very high resolution, 0.002 per cent of full scale. This VERNIER has a single shaft with a coarse, medium, and fine resolution potentiometer (refer to schematic diagram). The total shaft angular travel for the VERNIER is about 850 degrees. Its effective resolution is comparable to that of a 30 to 40-turn potentiometer.

The output amplitude is adjustable from 0 to 15V with the STEP attenuator on 0 db, 0 to 1.5V with the STEP attenuator on -20 db, and 0 to 0.15V with the STEP attenuator on -40 db.

4.3.4a Output Amplitude Control for Two Phase Power Oscillator.

The output amplitude VERNIER for two phase versions of the Power Oscillator may be one of two optional types:

1. Two gang potentiometer, one section for each phase. This potentiometer is located just ahead of the power amplifier in the circuit.

2. High resolution VERNIER plus STEP attenuator as described in paragraph 4.3.4 above. This output attenuator is located ahead of the phase splitting network in the circuit.

## Section V

## MAINTENANCE

### 5.1 CALIBRATION PROCEDURES, POWER OSCILLATOR

#### 5.1.1 Amplitude Calibration

To check amplitude flatness of the Oscillator it is necessary to utilize an AC instrument with a frequency flatness of 0.2% or better from 10 to 10,000 cps. An accurate AC differential or digital voltmeter are suitable instruments as long as their frequency response is flat. A thermal transfer standard with DC voltage reference could also be used.

A separate amplitude adjustment trimmer is provided for each frequency range. The trimmers are located as shown in Figure 5-1. If the amplitude flatness unloaded is not within ± 1.0% it can be adjusted as follows:

1. Set the frequency to 1,000.0 cps. "1" must be set on the most significant frequency selector (farthest to the left).

2. Set the VERNIER Frequency Control to the CALIBrate position.

3. Adjust DC BALance per paragraph 3.3.1

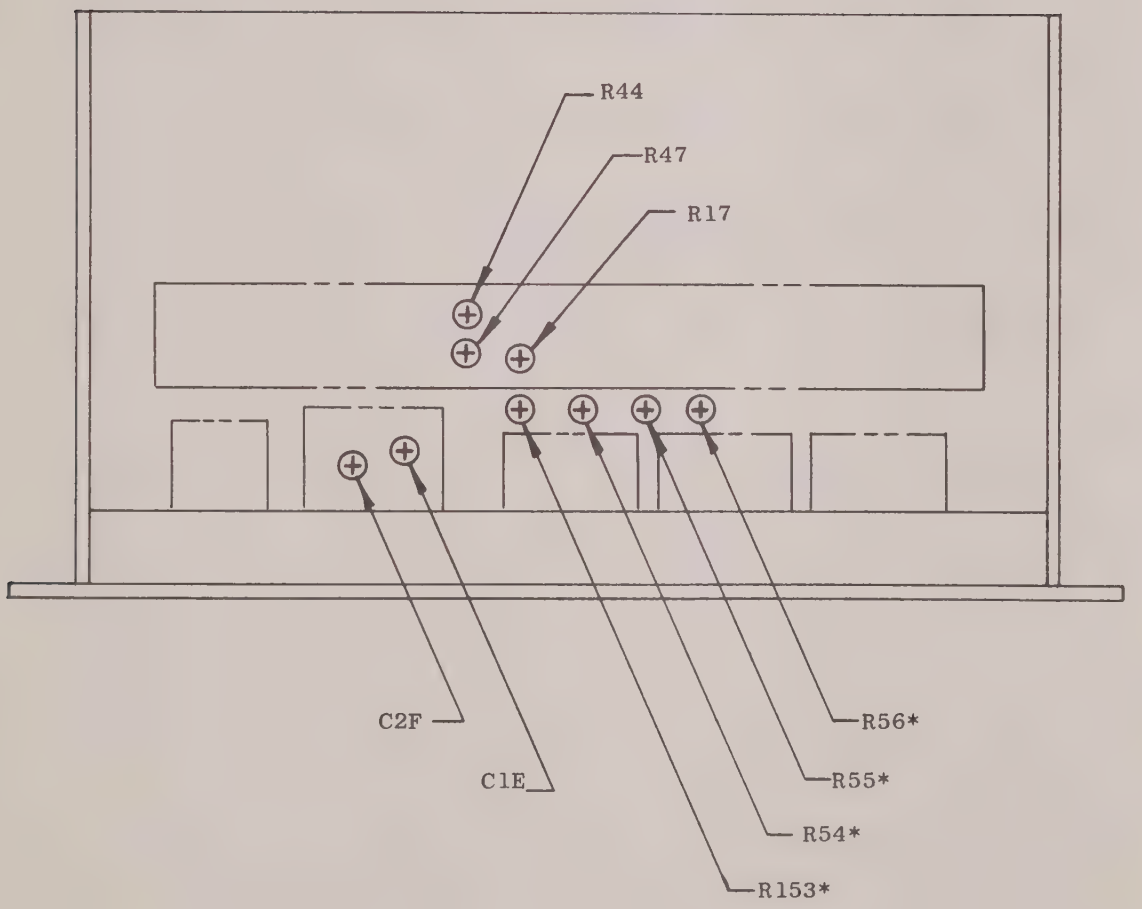
4. Set the ATTENUATION VERNIER and STEP control for maximum output. STEP at 0 db, VERNIER fully clockwise.

5. Check the maximum output voltage open circuit for 16.88VRMS ± 2% (16.54 to 17.22 VRMS). If voltage is not within these limits follow the procedure below:

   Diode clippers in the oscillator circuit are set about 5% above the maximum oscillator section output of 5VRMS. The gain in the power amplifier is 3.376, thus making the maximum power oscillator output 16.88VRMS. If the oscillator output is too high it may be clipped causing an increase in distortion.

   To set maximum oscillator section output voltage at 5VRMS proceed as follows:

   a. Invert power oscillator and remove bottom plate.
   b. Monitor oscillator output voltage at position 1 of switch SW8B. This point is terminal on right side (looking down) of rear wafer on DECADE Frequency Selector.
   c. Adjust R47 until oscillator output voltage is precisely 5VRMS.
   d. Recheck Power Oscillator output voltage. It should now be within the limits 16.54 to 17.22VRMS.




* 4 Digit RCD Power Oscillators only (RCD-7R)

Figure 5-1 Adjustment Trimmers for Power Oscillator, Location

6. If not already done, invert oscillator and remove bottom plate.

7. Reduce ATTENUATION VERNIER until the Power Oscillator output voltage is precisely 10VRMS. This voltage should be set to an accuracy of 0.2%.

NOTE: In the following steps use the frequency RANGE selector to change frequencies:

8. Set the frequency to 100.00 cps and adjust trimmer R44 for precisely 10VRMS output.

9. Set the output frequency to 20.000*cps and adjust R17 in a similar manner to precisely 10VRMS output.

*Frequencies as low as 20 cps or even 10 cps can be used assuming the monitoring meter is 0.2% accurate at these frequencies.

On Power Oscillators with matching transformers, the low frequency limit will vary from 10 to 100 cps depending on transformer model.

10. The amplitude adjustment for the 10,000. cps range is made in conjunction with the frequency calibration - par. 5.1.2.

5.1.2 Frequency Calibration RCD-6R

Normally, the Power Oscillator will operate for long periods of time without deterioration of frequency accuracy. To determine if the oscillator is within the ±1% specification, make the following checks:

1. Monitor the Output with a counter or frequency meter.

   a) Set the VERNIER Frequency Control to the CALIBrate position.

   b) Check the frequency at 10, 100, 1000, and 10,000 cps utilizing the DECADE Frequency Range Selector. This test verifies the range-to-range tracking.

2. If the above frequencies are all within the specifications of ±1%, the RCD is within calibration specification.

3. If the four ranges are within ±1% of each other, but are all either higher or lower than 1% from the nominal frequency, the VERNIER Frequency Control needs to be re-indexed as follows:

   a) Set the VERNIER control so that the four frequencies of 10, 100, 1000 and 10,000 cps are within ±1% as indicated on the external frequency monitor.

b) Loosen the set screws on the VERNIER Frequency Control knob taking care not to rotate the shaft.

c) When the set screws are loosened, rotate the knob so that the slot is opposite the CALIBrate position.

d) Retighten the set screws.

e) Recheck the ranges to insure that the shaft hasn't moved during this procedure.

5.1.2a Frequency Calibration RCD-7R

The RCD-7R is calibrated so that the output frequency will be within ±0.1% of the dialed-in-frequency from 10 to 9999 cps. To test this it is necessary to utilize a counter having an internal crystal reference with a stability of at least 1 part in 100,000 and an accuracy of better than 1 part in 10,000. Counters utilizing the line frequency as a reference are not suitable for calibration of the RCD-7R and should not be used. To check the frequency calibration proceed as follows:

1. Set the VERNIER Frequency Control to the CALIBrate position.

2. Check 10.000, 100.00, 1000.0, and 10000. cps utilizing the DECADE Frequency Range Selector. Insure that "1" is dialed in the Frequency Selector farthest to the left. (On 10 and 100 cps use the period mode of the counter). The output of the oscillator should be within ±0.1% of these four dialed in frequencies. If they are within ±0.1% of each other but are all either higher or lower than 0.1% from indicated frequency the VERNIER Frequency Control needs to be re-indexed. Loosen set screws on knob and re-index for best accuracy for the 4 ranges.

3. After the VERNIER Frequency Control is indexed each range can be individually adjusted as follows:

   a) Reset the oscillator to 10.000 cps (again use the period mode of the counter).

   b) If 10 cps is not within ±0.1% adjust R54 (See Fig. 5-1) for best accuracy from 10.000 to 90.000 cps in 10 cycle steps. The best overall accuracy can be obtained by adjusting for the frequency between 10 and 90 cycles that is farthest out of calibration.

   c) Set the oscillator to 100.00 cps. Check the frequency accuracy from 100.00 to 900.00 cps in 100 cycle steps. If any step is not within ±0.1% adjust R55 and correct the frequency that is farthest out of calibration.

   d) Set the oscillator to 1000.0 cps. Check frequencies from 1000.0 to 9000.0 cps in 1000 cycle steps. If any frequency is not within ±0.1% adjust R56 to correct for the frequency that is farthest out of calibration.

4. Check the tracking of the Frequency Selectors as follows:

a) Set the frequency to 1000.0 cps.

b) Check tracking of the most significant Frequency Selector by switching from 1000.0 to 9000.0 cps in 1000 cps steps.

c) Reset to 1000.0 cps and check the second Frequency Selector by switching from 1000.0 to 1900.0 cps in 100 cycle steps.

d) Check the tracking of the third Frequency Selector by switching from 1010.0 to 1090.0 cps in 10 cps steps.

e) RCD-7R only. Check the tracking of the fourth Frequency Selector by switching from 1001.0 to 1009.0 in 1 cps steps.

The procedure outlined in No. 4 above will check all resistors in the bridged-T frequency determining network. There are no individual adjustments for these resistors. If significant errors exist that put the unit out of specification, it is indicative of a malfunction in one of the switch wafers. Check to see that the switch contacts and wiper are free of foreign material.

5. If the 4th decade (10,000.cps) is not within ±1%, (±0.1% RCD-7R), it will be necessary to adjust Trimmers C1E, and C2F, located on the Frequency RANGE Selector switch (see Figure 5-1). Adjust as follows:

NOTE: Be sure that the VERNIER Frequency Control is in the CALIBrate position when making these adjustments.

a) In addition to the counter, monitor the output with an amplitude measuring instrument that will not appreciably load the oscillator output.

b) Turn the Frequency RANGE Selector until until the Power Oscillator is set for 10,000.cps.

c) Set ATTENUATION VERNIER for 10VRMS output.

d) Adjust C2F for a frequency of exactly 10,000.cps.

e) Check amplitude for 10V RMS. If not correct, adjust C1E to bring amplitude to 10V RMS.

f) Recheck frequency for 10,000.cps and readjust C2F if necessary to obtain 10,000.cps.

g) Continue to adjust C2F and C1E as above until optimum setting is obtained for best accuracy of frequency and amplitude. These points occur at the same time.

NOTE: C1E and C2F are interacting because the frequency is determined by their product and the amplitude by their ratio.

### 5.1.3 Power Amplifier Adjustments

1. DC BIAS adjustment, $I_C$, for each phase. When any of the output power transistors are changed, it will be necessary to adjust the collector current. Test jacks and an adjustment potentiometer are located on the rear of the chassis. To set the collector bias proceed as follows:

    a) With power ON, set VERNIER ATTENUATION control to zero (fully counterclockwise).

    b) Connect DC ammeter to BIAS test terminals.

    c) Press button marked PRESS TO TEST.

    d) Adjust trimmer for 100 ma current.

    e) Repeat this procedure for the second phase on two phase units as required.

Power Oscillators with Matching Output Transformers only.

2. Load Regulation. To adjust load regulation to essentially zero, monitor the output with a sensitive AC voltmeter. A differential meter is ideal for this.

    a) Connect the meter across the output.

    b) Connect and disconnect the load noting any change in output voltage.

    c) Adjust the Load Regulation control until the output voltage is equal - either full load or no load.

    NOTE: The load utilized for this adjustment should be resistive. An inductive load will tend to cause a voltage "kick" when disconnected, making the meter difficult to interpret. The power amplifier, however, is stable under inductive or capacitive loads.

## SHIPPING DAMAGE

This instrument should be inspected in accordance with instructions in Section II as soon as it is received. If it does not operate or has been damaged in shipment, a claim should be filed with the carrier. A complete report of the damage should be obtained by the claim agent and this report forwarded to Optimation, Inc. If this claim is not filed by you with the carrier, we cannot assist you in recovering the damage claim against the carrier. Upon receiving this report, we will advise you what to do with the instrument and arrange for repair or replacement. Be sure to include model and serial number when referring to this instrument.

## WARRANTY

Optimation, Inc. warrants each instrument manufactured by us to be free from defects in material (except vacuum tubes, fuses and lamps) and workmanship. Our obligation under this warranty is limited to adjustment or service of any instrument returned to us for that purpose and replacement of defective parts (except as noted above). This warranty is valid for one year after delivery to the original buyer when the instrument is returned, transportation prepaid, and after our inspection shows to our satisfaction that the instrument is defective. If the defect has been caused by misuse or improper operating conditions, this warranty is invalid. In this case, repairs can be made at a nominal charge, which we will quote before proceeding.

IF ANY DISCREPANCY DEVELOPS, TAKE THE FOLLOWING STEPS:

1. Notify Optimation, Inc., or our authorized representative in your area, giving full details of the problem. Include test data. If the question involves specifications, indicate measuring instruments you used in the test and the method of measurement. When we receive this data, we will send you service data or shipping instructions.

2. When you receive shipping instructions, send the instrument prepaid to us or the authorized repair facility we designate in the instructions.

## SHIPMENTS TO OPTIMATION

Shipments to Optimation, Inc. should be made by truck, REA Express, or Air Freight. Utilize the original packing container, if possible. It is expressly designed to ship our products safely. Otherwise, use a "box-within-a-box" with at least three inches of shock absorbent material surrounding the inner box. The instrument must be secure in the inner box and the outer box must be rigid.

Do not ship systems with more than one chassis intact, except via electronic van. Each chassis should be packed individually.

We are confident you will find Optimation instruments excellent and will look forward to any comments or questions you may have with regard to their use or application. May we hear from you?

Thank you.

OPTIMATION, INC.

OPTIMATION, INC.

# 15 VA PRECISION AC POWER SOURCE

## FEATURES

AC15R

* **POWER OUTPUT 15 VA** — from .1Hz to 20 kHz, down 3 db at 100 kHz. Overload protection with indication is provided.

* **LOW DISTORTION .05%** — at 15VA from 90 Hz to 10 kHz is provided by linear circuitry — sophisticated in concept yet simple in design.

* **STABLE AMPLITUDE 20ppm** — with option H is achieved with a very stable amplitude regulator in the oscillator section plus all silicon, solid state power amplifier with highly stabilized gain.

* **WIDE FREQUENCY RANGE .1 Hz to 100 kHz** — is set and read directly in Hz by means of 3 or (optionally) 4 digit selectors and a moving decimal point.

* **OUTPUT VOLTAGE TO 150V** — is available when optional transformer is included — frequency range 45 Hz to 100 kHz. Direct output voltage of 15V is available without transformer down to 0.1 Hz.

## SPECIFICATIONS

**FREQUENCY**

| | |
|---|---|
| RANGE, Direct in-line reading (10 to 99,900 Hz with Xfmr., option "T") | 0.1 to 99,900 Hz |
| ACCURACY, 10 to 99,900 Hertz | 1% |
| With option 'B', 10 to 9,999 Hertz | 0.1% |
| VARIATIONS, 1 hour, constant temperature | 100 ppm |

**OUTPUT**

| | |
|---|---|
| POWER, RMS, Direct coupled, 0.1 to 20,000 Hertz (—20% @ 0.1Hz) | 15VA ±10% |
| Transformer coupled, 40 to 20,000 Hz | 15VA ±10% |
| VOLTAGE RANGE, Direct coupled, no load (See curves reverse side) | 0 to 15 VRMS |
| Transformer coupled, option "T", no load, 3 taps | 0 to 37 V, 0 to 75 V, or 0 to 150 VRMS |
| AMPLITUDE INSTABILITY, Short term | 100 ppm |
| Short term, with option "H" | 20 ppm |
| REGULATION, LINE, 10% variation | within 100 ppm |
| LOAD, No load to full load | internal impedance adjustable through zero |
| DISTORTION, harmonic, 90 to 10,000 Hertz | 0.05% |
| HUM AND NOISE, % rated output | 100 ppm |
| MODULATION, near line frequency | 0.1% |
| AMPLITUDE CONTROL, Step (option H, 11 steps) | x1, x0.1, x0.01 |
| Vernier resolution (option H, 5 ppm) | 0.1% |
| **POWER REQUIREMENTS,** 105 to 125 VAC or 210 to 250 VAC, 50 to 400 Hz | 60 VA |
| **SIZE** | Bench 3½H x 18W x 16D — RACK 3½H x 19W x 16D |

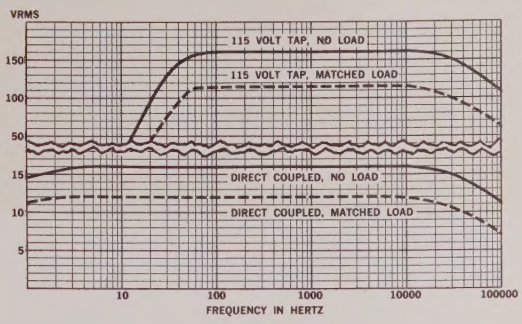
See typical performance data and optional features on reverse side.

# PERFORMANCE DATA*

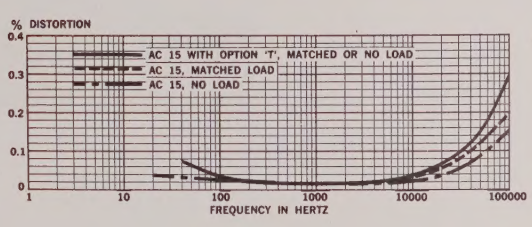
**VOLTAGE OUTPUT** over the frequency range from 1 Hz to 100,000 Hz is illustrated — direct coupled and transformer output (option T).

Curves show maximum voltage available for no load and matched load conditions.

Maximum output voltage for the remaining two transformer taps (option T) may be obtained by dividing values shown by 2 or 4 respectively.




**DISTORTION VS. FREQUENCY** is shown with matched load and no load for both direct coupled and output transformer coupled versions. This low distortion is provided by high purity oscillator and a unique solid state amplifier.




**PRICE** . . . AC 15, Bench unit — $1230 . . . . . AC 15R, Rack mount — $1190

## OPTIONAL FEATURES

| | OPTION | PRICE |
|---|---|---|
| **ACCURATE FREQUENCY,** 0.1% from 10 to 9999 Hz, 0.3% at 90,000 Hz, with a 4 digit setability (plus vernier). This option can eliminate a frequency counter in applications requiring a frequency monitor. | B | $140. |
| **STABLE FREQUENCY** with variations <10 ppm at constant temperature and temperature coefficient under 30 ppm/°C, 10 to 9999 Hz. This option provides frequency stability comparable to a tuning fork and yet retains the advantage of variable frequency. Option "B" must also be ordered when specifying option "C". | C | $300. |
| **INFINITE RESOLUTION FREQUENCY VERNIER** potentiometer provides high resolution frequency setability—maximum △f 0.25% of frequency set. Available with option B only. | D | $ 25. |
| **EXTERNAL FREQUENCY SYNC** — an input is provided to facilitate synchronization of the AC15 to an external frequency standard. External input 3 — 5 VRMS required. | G | $ 25. |
| **HIGH RESOLUTION AMPLITUDE CONTROL.** An eleven-position coarse-step attenuator is mounted concentrically with a 3-stage high resolution vernier to provide output resolution under 5 ppm. Short term instability is improved to 20 ppm. | H | $100. |
| **FREQUENCY COUNTER MONITOR TERMINAL** provides a low impedance output for connection to a counter. This eliminates output distortion due to non-linearity of counter impedance. | J | $ 25. |
| **SQUARE WAVE OUTPUT** or sine wave, switch selectable. Square wave amplitude to 27V peak-peak — to 65, 135, or 270V peak-peak with option "T". | S | $125. |
| **OUTPUT TRANSFORMER** with step-up taps of 2.5, 5, and 10X, rear-mounted switch selectable, provides output voltages to 150V open circuit or 115V matched load. Lowest frequency for full power output is 45 Hz with transformer. Other taps on special order. | T | $ 75. |

**TO ORDER OPTIONAL FEATURES,** specify features desired by respective letter and add price of selected options to the basic unit price.

* Performance data shows typical performance. AC 15 may be ordered to specifications listed on front of data sheet.

**WARRANTY**
Optimation instruments are manufactured and tested under an exacting quality control program. Conservatively rated, premium components are used in our instruments to insure long reliable operation within specifications. . . We warrant each instrument to be free from defects in material and workmanship. We will adjust, service and/or replace any defective parts (tubes excepted), in instruments returned to us, for 1 year after delivery to the original buyer.

## REPRESENTED BY:

Price and/or specifications subject to change without notice.

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